Standardization of light and nutrition conditions for the protected cultivation of some horticulture crops

A Synopsis of the proposed work for the degree of

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In

Botany

Submitted by

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INTRODUCTION

Protected cultivation is a technique for the off - season crop cultivation and the plants are grown under fully or partially controlled climatic conditions such as temperature, humidity, CO2, etc. Protected cultivation of vegetables offers distinct advantages of quality, productivity and favours high yield and fruit quality. Therefore, farmers can significantly increase their income (Ummyiah et al. 2017). Aim of the present study is to design modern geoponic, hydroponic and aeroponic systems with artificial illumination, and to set various climatic conditions such as temperature, humidity, CO2, light intensity, photoperiod. To optimize yield and quality of the produce tomato, cucumber, capsicum, and cape gooseberry some other crops will be grown under protected cultivation and conditions of nutrition, temperature, light, irrigation and humidity will be diversed for increased productivity.

Tomato (*Solanum lycopersicum*)

Tomato (*Solanum lycopersicum*) is an important vegetable crop belonging to Solanaceae and originated from the America chiefly Bolivia, Chile, Colombia, Ecuador and Peru (Peralta et al. 2008; Blanca et al. 2012). There are many culinary products prepared from ripened tomato fruit such as powder, ketchup, sauce, soup etc. and these are rich source of minerals, vitamins and lycopene (a pigment). Lycopene is a carotenoids and has lot of health benefits besides being anti-cancerous and cardio protective diseases (Giovannucci et al. 1995; Dias et al. 2012). Global production of tomatoes is 170 million tons. China is the largest producer of tomato followed by in 2018(www.Thehindubusinesline.com) viewed in September-2019 India and US. In India main tomato producing states are Madhya Pradesh, Karnataka, Odisha, Telangana, Bihar, Andhra Pradesh, Maharashtra, West Bengal, and Chhattisgarh etc. According to National Horticulture Board (NHB) 2019, currently all India production of tomato fruits is 20.5 MT. Tomato fruit is also rich in vitamin A, B6, K and in addition has ions, zinc and folate.

Table 1: Following are the optimum growth condition of crop under protected cultivation

Crop	Temperature Day (°C)	Temperature Night (°C)	Humidity (%)	Light Intensity (lux)
Tomato	22-27	15-19	50-65	50000-60000

Source - Precision farming development centre (ICAR-CISH), 2015 Classification

Division Magnoliophyta

Class Magnoliopsida

Order Solanales

Family Solanaceae

Genus *Solanum*

Species *lycopersicum*

Source- (USDA), 2019

Morphology of plant

Tomato plant height reaches about 3 meter and has a strong taproot. Stem is highly delicate and has trichomes near the upper region. Inflorescence produces 8-12 flowers. Leaves are alternate, fruit is a typical berry, with orange, red or pink colour (OECD, 2008).

Capsicum (*Capsicum annuum*)

Capsicum (*Capsicum annuum*) is an important vegetable crop and belongs to the Solanaceae. It originated from Central and South America (Moscone et al. 2007). In India Capsicum is cultivated in Andhra Pradesh, Karnataka, Tamil Nadu and Maharashtra. According to National Horticulture Board (2019) all India production of capsicum fruit was 496 MT. Capsicum is rich in vitamin A and C etc. Capsaicin is an most important alkaloid, found in the pericarp of the fruit and finds use curing rheumatic problems, hypertension, diabetes and atherosclerosis (Raj et al. 2015).

Table 2: Following are the optimum growth condition of crop under protected cultivation

Crop	Temperature Day (^{o}C)	Temperature Night (^{o}C)	Humidity (%)	Light Intensity (lux)
Capsicum	21-24	18-20	50-65	50000-60000

Source - Precision farming development centre (ICAR-CISH), 2015 Classification

Division Magnoliophyta

Class Magnoliopsida

Order Solanales

Family Solanaceae

Genus *Capsicum*

Species *annuum*

Source – (USDA), 2019

Plant morphology

The capsicum plant is an annual herb with 0.5-1.5 meter height. Root is a strong taproot, stem has soft wooded, branched and irregularly pointed. Leaves are alternate, simple and dark green colour. Flowers are pentamerous, campanulated with bear singly on the stem node and found generally white and purpled flowers, Fruits is a berry and pericarp could be red, yellow or green (Zhigila et al. 2014)

Cucumber (*Cucumis sativus*)

Cucumber (*Cucumis sativus*) belongs to the family Cucurbitaceae and originated from Asia, wild varieties are found in India while its closely related members are found in Eastern Himalayan region (Sebastian et al. 2010). According to National Horticulture Board (NHB) (2019) all India production of cucumber fruit was 16.1 MT. Cucumber contains 93 to 97% water. The aqueous extract of this fruit contain large amount of cucurbitacin (Sood et al. 2012), and these compounds responsible for the various disease treatment such as cancer, asthma, coughs, sore throats, toothache, diabetes and cardiovascular diseases (Wahyuni et al. 2013).

Table 3: Following are the optimum growth condition of crop under protected cultivation

Crop	Temperature Day (^{o}C)	Temperature Night (^{o}C)	Humidity (%)	Light Intensity (lux)
Cucumber	24-27	18-19	60-65	50000-60000

Source -Precision farming development centre (ICAR-CISH), 2015 Classification

Division Mgnoliophyta

Class Mgnoliopsida

Order Violales

Family Cucurbitaceae

Genus *Cucumis*

Species *sativus*

Source – (USDA), 2019

General plant description

Cucumber is a monoecious herb and climbing plant with very soft, hairy and branched stem. Plant

hight may reach up to 5 meter, with tendrils. The leaves are very smooth, alternate, simple, and 3-7 plamately lobed, leaf margins are dented. Flower are yellow and star shaped, pentamerous, unisexual, pistilated, solitary, regular. Generally fruit are pepo, and the cylindrical and 15-18cm long (Urooj et al. 2016)

Cape gooseberry (*Physalis peruviana*)

Cape gooseberry plant is the native of South America, mainly Peru, Colombia and Ecuador (Fischer et al. 2012). This is a small fruit and contains vitamin A and C, alkaloid, carotenoides and many bioactive compounds. Fruit and leaves extract is antifungal, antioxidant, anti- inflammatory, anticancerous, and insect repellent with antidiabitic properties in nature (Puente et al. 2011).

Table 4: Some nutritive values of Cape gooseberry pulp (mg/100g)

Carotene	1.6 mg/100g
Moisture	78.9 g/100g
Calcium	8.0 mg/100g
Iron	1.2 mg/100g
Protein	0.05–0.3g/100g
Phosphorus	55.3 mg/100g
Carbohydrate	19.6 g/100g
Ascorbic acid	43.0 mg/100g

Source - Ramadan and Mörsel (2004)

Classification

Division Magnoliophyta

Class Magnoliopsida

Order Solanales

Family Solanaceae

Genus *Physalis*

Species *Peruviana*

General plant description

It is a perennial shrub (2-2.5meter plant height) having reticulate branches, root system may reach 30-80cm and stem is herbaceous, soft, woody containing 8-10 nodes, leaves are generally simple and heart shape. Flowers are pentamerous in yellow colour and fruit is a typical berry (Ramirez et al. 2013)

Table 5: Following are the optimum growth condition of crop under protected cultivation

Crop	Temperature Day (^{o}C)	Temperature night (^{o}C)	Humidity (%)	Rain (mm)
Cape gooseberry	22- 28	7-13	70 - 80	1000 – 1800

Source - (Puente et al. 2011).

Internet of thing (IOT) technique

IOT technique is a modern technology, based on sensors. This technique is used for the monitoring temperature, humidity, radiation etc. The greenhouse has controlled environment as conditions like temperature, humidity, CO2, O2, relative humidity and aeration. Heater, ventilator fens, foggers, drip irrigation and other systems are automatically operated for improved crops quality and production (Hernández et al. 2002). This is a real time automation system, which help in irrigation and fertigation (Singhal et al. 2010; Kadam et al. 2018; Karthikeyan et al. 2017). This is a fixed system for control of up and down challengeable weather condition with the help of network gateway system inside the polyhouse.

Significance of the work

With increasing population of the world main resources of crop cultivation like water, lands etc. are being depleted. Therefore, the present study aims to fulfill need of the human being regarding vegetables and fruits with the shortage of water, soil, air and land.

During the protected cultivation, farmers can cultivate crop at very large scale throughout the year and they can grow off - season crop that can give marketable cost of product with high prices as compared to seasonal crop.

The fruit, which grow under protected cultivation, have improved photochemical properties of that consecutive effect on the secondary metabolites of that fruit. Beside this are fruit growing under greenhouse are free from diseases thus have no negative effect on human health.

The expected outcome of this work and to grow crop on a large scale so that farmers can get enhanced price of the crop as compare to crop growing in field condition seasonally.

OBJECTIVES

In view of the importance of the present study has been undertaken with the following objectives

Following objectives could be formulated for this study:

1. Establishing selected structures for hydroponics, aeroponics and vertical farming.
2. Study effect of varying light conditions as intensity and wavelength on growth, physiological attributes and yield in the selective horticulture crops.
3. Optimizing functioning of hydroponics, aeroponics and vertical farming in terms of periodicity of nutrition, quantitative and qualitative aspects of the nutrient solution, ambient greenhouse conditions and other related conditions.

REVIEW OF LITERATURE

According the Adams et al. (2001) studied the effect of temperature for early fruit ripening and fruit growth. The study revealed that low temperature (about $14^{O}C$) reduces fruit growth and delayed fruit ripening but on the other hand relatively high temperature i.e. about $20 – 26^{O}C$ shows reverse effects on both fruit ripening and fruit growth. Diana et al. *(*2007) studied the effect of fertilizer N60 P60 K60 on two different varieties of tomatoes and it was found that the biochemical parameters like phenolic compound, ascorbic acid content, lycopene, sugar content and total antioxidant activity increases significantly while comparing with the control variety. Dunage et al. (2009) reported that hydroponic system improves the yield and profit of tomato crop production significantly with a benefit cost 5.19 of tomato under the net house. (Rubio et al. 2010) reported the effect of three different concentrations of calcium (1.5, 4, 8) and potassium (2.5, 4 and 8) fertilizer on the yield and quality of sweet pepper fruit. According to this particular study, the fruit size increased significantly and TSS decreased considerably with the higher concentration of calcium. In addition it was also observed that low Ca or high Ka levels reduces both root and shoot dry matter. Lin et al. (2013) reported that lettuce plant have also been grown in hydroponic system with controlled environmental condition. In this study lettuce plants were treated with red and blue light and observed the different effects on plant including leaf pigments like chlorophyll and carotenoids, soluble proteins, sugars and nitrates, and other qualitative

characteristics like sugariness, shape, and color and the concluding result was maximum increase in plant production and improved quality of vegetables. Nangare et al. (2015) studied the effect of 3 different light intensities i.e. 35%, 50% and 75% of net houses on tomato plant and observed its effect in several different months according to variable weather conditions and compared with the tomato plants grown in open field. In this experiment, there was no large difference of temperature and humidity at 75% shade or open field and the fruit yield was also very low but at 35% and 50% shade house, tomato yield were increased effectively. Chandra and group observed that the biochemical properties of some leafy vegetables such as basil, chard, parsley, red kale and few fruit crop like bell pepper, cherry tomatoes, cucumber and squash grown in aeroponic system. The systems were comparing with traditional cultivation and show the better results in antioxidant properties, yield of product and bioactive compounds Chandra et al. (2014). Hoffmann and group observed the effect of highest and lowest blue light on pepper plants grown under UV- stressed conditions in which it was reported that higher light intensity i.e. 62% blue light increased the photosynthetic rate as well as photochemical efficiency of non-photochemical quenching plant in comparison with lower light intensity Hoffmann et al. (2015). The study also concluded that morphological and biochemical parameters are influence by the higher exposure of blue light. In hydroponic system balanced nutrient is very much essential for the maximum growth of the plant and yield. Lee et al. (2017) study the effect of consumption of nutrient solution by tomato plants on their growth and yield. However, the study observed the major and minor nutrients variation controlled by inductively coupled plasma-optical emission spectroscopy (ICP-OES), ion chromatography (IC), ion specific electrodes, and/or colorimetric methods. Woldemariam et al. (2018) analyzed the effect of different concentration of potassium like (0, 50, 100, 150, 200, 250, 300, 350 and 400 kg/ha) on tomato's fruit yield and reported that 150kg/ha of potassium enhanced plant growth and fruit yield much effectively. Malik et al. (2018) work on the hydroponic cultivation of tomatoes, and observed the average yield of hydroponic tomatoes cultivation i.e. 161.8 ton per hectare which is quite higher in comparison with the tomato with 10.7 ton per hectare grown in open field. Argade et al. (2018) cultivated cherry tomato and a different genotype variety of tomato (KSP-113) with three different shade intensities i.e. 35, 50, and 75 %, and analyzed their effects on fruit yield, flower, the weight of fruit cluster and plant height and it

was observed that the maximum yield i.e. 579.44qha^{-1} and 503.88qh $^{-1}$ of both variety was observed at 35% shading intensity for plant height and yield of fruit. Singh et al. (2019) reported that the effect of three fertigation label and water use efficiency on three varieties cucumber growing in soilless media under partially controlled naturally ventilated polyhouse, for the improving water use efficiency and in comparison with traditional cultivation. This study revealed that water use efficiency reached its highest peak value 179.9 and lowest peak value 120.6 kg m^{-3}. Kong et al. (2019) reported that the effect of four light qualities i.e. pure red and blue, uupure red and blue light (i.e B+FR, B+UVA) on arugula (*Brassica eruca* L.,cabbage (*Brassica oleracea*, mustard *Brassica juncea*, and kale (*Brassica napus*) on their growth and morphology in which it is revealed that minute effect is detected in case of unpure light and not in pure light. Hemming et al. (2019) reported the study of cucumber plant grow controlled condition and monitored by the sensors on plant growth, fruit yield. Resulted observed very essential data by artificial intelligence Singh et al. (2019) conducted an experiment on hydroponic system fertilizers. In this study, fertilizer dose on fruit yield and quality shape and shoot fresh and dry weight etc. of two cultivars of capsicum annuum and eggplant and expose the fertilizer dose of NPK like (5N- 4.8P-21.6K) for the maximum yield and shoot dry and fresh weight was obseved. From this experiment, it was concluded that different fertilizer dose (7N-3.9P-4.1K) have no significant effect on fruit quality of cultivars.

METHODOLOGY

- ❖ Hydroponic, aeroponic and geoponic system will be set up in Dayalbagh Educational Institute.

- **Germination of seedlings**

Seed will be procured from urban/local market and cultivate in the polyhouse of Dayalbagh Educational Institute, Agra.

Seed will be germinated in portrays in coco peat.

- **Controlled environment of polyhouse**

For the weather condition like temperature, humidity will be regulated by automated system e.g. ventilation fens, foggers, pad-cooling system and various sensors.

- **Irrigation and fertigation**

Drip system used for irrigation and fertigation during the protected cultivation. Some fertilizers will be used for fulfill of nitrogen, potassium and phosphorus (NPK).

- **Pruning and tying**

Pruning will be at specific interval of time to remove diseased plant part and leaves.

❖ Study effect of varying light conditions as intensity and wavelength on growth, physiological attributes and yield in the selective horticulture crops.

- **Treatment**

❖ Plants will be cultivated in different systems of protected chambers like Hydroponic, Aeroponic and Geoponic. Plants will be treated with different light intensity, wavelength and nutrients.

- **Growth Parameter**

Growth parameters will be obtained such as plant height, dry weight and fresh weight of plant, leaf area etc.

- **Physiological and biological parameters**

Physical parameters will be analyzed such as leaf gas exchange propertie (Stomatal conductance, Photosynthesis rate, Transpiration) will be used by Infrared gas analyzer, Chlorophyll and carotenoids content of leaf.

Biochemical parameters will be analyzed (Antioxidants, Lycopene, Sugar content of inner and outer part of fruit.

- Chlorophyll and carotenoids content analysed by the method (Lichtenthaler et al.1987).
- Sugar content measured by the method rfrectrometer.
- Phenolic compound determine by the method given by (Singleton et al. 1965).
- Flavonoides contents of the plant parts determind by method (Chang et al. 2002; Pourmorad et al. 2006).
- Lycopene content of the fruit analyzed by the HPLC and Spectrophotometric method.

- **Yield parameters**

Yield parameters will be conducted weight of fruit per plant, weight of fruit total plant, cluster number of per plant, flower number of per cluster, fruits number of per cluster, fruit set percentage.

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